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Technology Assessment Program

Ballistic Helmets

NIJ Standard-0106.01

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The Technology Assessment Program is sponsored by the Office of Development, Testing, and Dissemination of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which created NIJ and directed it to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

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Paul Cascarano, Assistant Director
National Institute of Justice

Technology Assessment Program

NIJ Standard for Ballistic Helmets

Supersedes NILECJ-STD-0106.00 dated September 1975

A Voluntary National Standard Promulgated by the National Institute of Justice.

December 1981

U.S. DEPARTMENT OF JUSTICE
National Institute of Justice

U.S. DEPARTMENT OF JUSTICE
National Institute of Justice

JAMES L. UNDERWOOD

Acting Director

ACKNOWLEDGMENTS

This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Ralph A. Gorden, Jr., Manager, Protective Equipment Program, and Lawrence K. Eliason, Chief of LESL. The technical research was performed by Nicholas J. Calvano of the NBS Center for Consumer Product Technology. The standard has been reviewed and approved by the Technology Assessment Program Advisory Council and adopted by the International Association of Chiefs of Police (IACP) as an IACP Standard.

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NIJ STANDARD FOR BALLISTIC HELMETS

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FOREWORD

This document, NIJ Standard-0106.01, Ballistic Helmets, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is produced as part of the Technology Assessment Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment must meet to conform to the needs of criminal justice agencies for high quality service. Purchasers can use the test methods described in this report to determine firsthand whether a particular piece of equipment meets the standards, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements, with compliance guaranteed by the vendor or attested to by an independent laboratory.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance about the capabilities of ballistic helmets, user guides also are published. The guides explain in non-technical language how to select equipment capable of the performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Program Manager for Standards, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Chief, Law Enforcement Standards Laboratory, National Bureau of Standards, Washington, DC 20234.

Lester D. Shubin
Program Manager for Standards
National Institute of Justice

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NIJ STANDARD FOR BALLISTIC HELMETS

1. PURPOSE AND SCOPE

The purpose of this standard is to establish performance requirements and methods of test for helmets intended to protect the wearer against gunfire. Requirements for face shields are not included in this standard. The standard is a revision of NILECJ-STD-0106.00, dated September 1975.

This revision redefines the classification system, and establishes threat levels and test rounds that are consistent with companion NIJ standards for ballistic protective equipment and materials [1,4]*.

2. CLASSIFICATION

Ballistic helmets covered by this standard are classified into three types, by level of performance.

The ballistic threat posed by a bullet depends, among other things, on its composition, shape, caliber, mass, and impact velocity. Because of the wide variety of cartridges available in a given caliber, and because of the existence of hand loads, helmets that will defeat a standard test round may not defeat other loadings in the same caliber. For example, a helmet that prevents penetration by a 357 Magnum test round may or may not defeat a 357 Magnum round with higher velocity. Similarly, for identical striking velocities, non-deforming or armor piercing rounds pose a significantly greater penetration threat than an equivalent lead core round of the same caliber. The test ammunition specified in this standard represent common threats to the law enforcement community.

2.1 Type I (22 LR—38 Special)

This helmet protects against the standard test rounds as defined in paragraph 5.1.1. It also provides protection against lesser threats such as 12 gauge No. 4 lead shot and most handgun rounds in calibers 25 and 32.

2.2 Type II-A (Lower Velocity 357 Magnum—9 mm)

This helmet protects against the standard test rounds as defined in paragraph 5.1.2. It also provides protection against lesser threats such as 12 gauge 00 buckshot, 45 Auto., 22 caliber Long Rifle High Velocity (rifle), High Velocity 38 Special and some other factory loads in caliber 357 Magnum and 9 mm, as well as the threats mentioned in paragraph 2.1.

2.3 Type II (Higher Velocity 357 Magnum—9 mm)

This helmet protects against the standard test rounds as defined in paragraph 5.1.3. It also provides protection against lesser threats such as 12 gauge 00 buckshot, 45 Auto., 22 caliber Long Rifle High Velocity (rifle), High Velocity 38 Special and most other factory loads in caliber 357 Magnum and 9 mm, as well as the threats mentioned in paragraph 2.1.

2.4 Special Type

A purchaser having a special requirement for a level of protection other than one of the above standards should specify the exact test rounds to be used, and indicate that this standard shall govern in all other respects.

*Numbers in brackets refer to references in appendix A.

3. DEFINITIONS

3.1 Angle of Incidence

The angle between the line of flight of a bullet and the perpendicular to the plane tangent to the point of impact. See figure 1.

3.2 Basic Plane

The plane through the centers of the external ear openings and the lower edges of the eye sockets. See figure 2.

3.3 Coronal Plane

The plane, perpendicular to the basic and mid-sagittal planes, which passes through the centers of the external ear openings. See figure 2.

3.4 Fair Hit

A hit that impacts the helmet at an angle of incidence no greater than 5°, and is at least 5 cm (2 in) from a prior hit or the edge of the helmet. A bullet that impacts too close to the edge or a prior hit and/or is of too high a velocity, but does not penetrate, shall be considered a fair hit for the determination of penetration.

3.5 Full Metal Jacketed Bullet (FMJ)

A bullet made of lead completely covered, except for the base, with copper alloy (approximately 90 copper-10 zinc).

3.6 Jacketed Soft Point (JSP)

A bullet made of lead completely covered, except for the point, with copper alloy (approximately 90 copper-10 zinc).

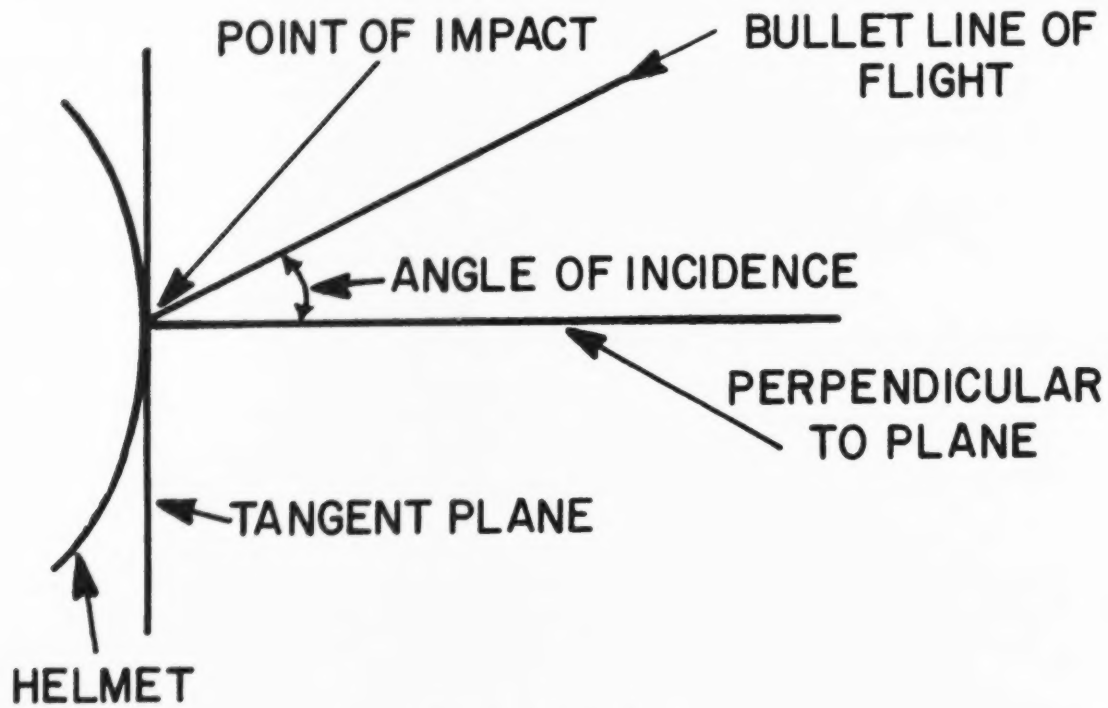

FIGURE 1. Angle of incidence.

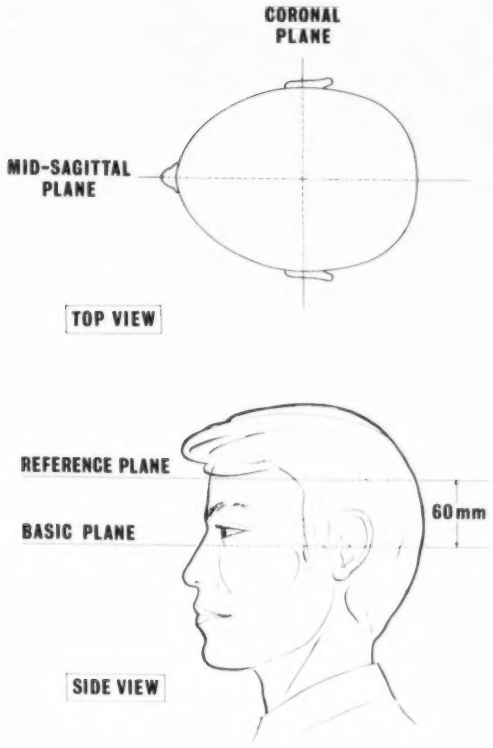

FIGURE 2. Head planes.

3.7 Lead Bullet

A bullet made of lead alloyed with hardening agents.

3.8 Mid-Sagittal Plane

The plane, perpendicular to the basic and coronal planes, which symmetrically bisects the head. See figure 2.

3.9 Penetration

Perforation of a witness plate by any part of the test specimen or test bullet, as determined by the passage of light when the witness plate is held up to a 60-W light bulb.

3.10 Reference Plane

The plane 60 ± 1 mm ($2.36 + 0.04$ in) above and parallel to the basic plane. See figure 2.

3.11 Witness Plate

A thin sheet of aluminum whose perforation serves as a means of determining penetration.

4. REQUIREMENTS

4.1 Sampling for Test

Three helmets, size 7 1/4 and selected at random, shall constitute a test sample.

4.2 Test Sequence

The helmets shall be examined to determine compliance with the requirements of paragraphs 4.3 through 4.6, and shall then be tested for compliance with the requirements of paragraphs 4.7 and 4.8 in that sequence.

4.3 Projections

The helmets shall have no rigid projections that protrude from the inside shell surface.

4.4 Openings

The helmets shall have no slits, holes, or other openings.

4.5 Workmanship

The helmets shall be free from dents, blisters, cracks, crazing, chipped or sharp corners and other evidences of inferior workmanship.

4.6 Labeling

Each helmet shall be permanently and legibly labeled so that the label can be easily read without removing padding or any other permanent part, and shall include the following information:

a) name, designation, or logo of the manufacturer
b) type of helmet, according to section 2 of this standard
c) size
d) month and year of manufacture
e) lot number

4.7 Ballistic Penetration

Two helmets shall be tested for resistance to ballistic penetration in accordance with paragraph 5.2. Penetration by any fair hit shall constitute failure. The detailed ballistic performance requirements are summarized in table 1.

4.8 Ballistic Impact Attenuation

One helmet shall be tested for ballistic impact attenuation in accordance with paragraph 5.3. No measured peak acceleration shall exceed 400 g_n (400 times the acceleration due to gravity).

5. TEST METHODS

5.1 Test Equipment

It should be noted that hand-loaded ammunition may be required to achieve some of the bullet velocities required in the following paragraphs.

5.1.1 Type I Test Weapons and Ammunition

5.1.1.1 22 LR

The test weapon may be a 22 caliber handgun or test barrel. The use of a handgun with a 15 to 16.5 cm (6 to 6.5 in) barrel is suggested. Test bullets shall be 22 Long Rifle High Velocity lead, with nominal masses of 2.6 g (40 gr) and measured velocities of 320±12 m (1050±40 ft) per second.

5.1.1.2 38 Special

The test weapon may be a 38 Special handgun or test barrel. The use of a handgun with a 15 to 16.5 cm (6 to 6.5 in) barrel is suggested. Test bullets shall be 38 Special round-nose lead, with nominal masses of 10.2 g (158 gr) and measured velocities of 259±15 m (850±50 ft) per second.

TABLE 1. *Test summary*

Helmet type	Test variables: Test ammunition	Nominal bullet mass	Suggested barrel length	Required bullet velocity	Performance requirements: Required fair hits per helmet part	Permitted penetrations
I	22 LRHV Lead	2.6 g 40 gr	15 to 16.5 cm 6 to 6.5 in	320±12 m/s 1050±40 ft/s	4	0
	38 Special RN Lead	10.2 g 158 gr	15 to 16.5 cm 6 to 6.5 in	259±15 m/s 850±50 ft/s	4	0
II-A	357 Magnum JSP	10.2 g 158 gr	10 to 12 cm 4 to 4.75 in	381±15 m/s 1250±50 ft/s	4	0
	9 mm FMJ	8.0 g 124 gr	10 to 12 cm 4 to 4.75 in	332±15 m/s 1090±50 ft/s	4	0
II	357 Magnum JSP	10.2 g 158 gr	15 to 16.5 cm 6 to 6.5 in	425±15 m/s 1395±50 ft/s	4	0
	9 mm FMJ	8.0 g 124 gr	10 to 12 cm 4 to 4.75 in	358±15 m/s 1175±50 ft/s	4	0

Abbreviations:
FMJ—Full Metal Jacketed
JSP—Jacketed Soft Point
LRHV—Long Rifle High Velocity
RN—Round Nose

5.1.2 Type II-A Test Weapons and Ammunition

5.1.2.1 Lower Velocity 357 Magnum

The test weapon may be a 357 Magnum handgun or test barrel. The use of a handgun with a 10 to 12 cm (4 to 4.75 in) barrel is suggested. Test bullets shall be 357 Magnum jacketed soft point, with nominal masses of 10.2 g (158 gr) and measured velocities of 381±15 m (1250±50 ft) per second.

5.1.2.2 Lower Velocity 9 mm

The test weapon may be a 9 mm handgun or test barrel. The use of a handgun with 10 to 12 cm (4 to 4.75 in) barrel is suggested. Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and measured velocities of 332±15 m (1090±50 ft) per second.

5.1.3 Type II Test Weapons and Ammunition

5.1.3.1 Higher Velocity 357 Magnum

The test weapon may be a 357 Magnum handgun or test barrel. The use of a handgun with a 15 to 16.5 cm (6 to 6.5 in) barrel is suggested. Test bullets shall be 357 Magnum jacketed soft point, with nominal masses of 10.2 g (158 gr) and measured velocities of 425±15 m (1395±50 ft) per second.

5.1.3.2 Higher Velocity 9 mm

The test weapon may be a 9 mm handgun or test barrel. The use of a handgun with a 10 to 12 cm (4 to 4.75 in) barrel is suggested. Test bullets shall be 9 mm full metal jacketed, with nominal masses of 8.0 g (124 gr) and measured velocities of 358±15 m (1175±50 ft) per second.

5.1.4 Chronograph

The chronograph shall have a precision of 1 μs and an accuracy of 2 μs. Its triggering devices shall be of either the photoelectric or conductive screen types.

5.1.5 Penetration Test Headforms

Each penetration test headform shall be size 7 1/4 and shall have the dimensions shown in figure 3. The sagittal penetration type shall be so modified that it can rigidly hold a witness plate in the coronal plane as shown in figure 4. Conversely, the coronal penetration type shall be able to hold a witness plate in the sagittal plane, as shown in figure 4.

5.1.6 Impact Test Headform

The impact test headform shall be size 7 1/4, shall have the dimensions given in figure 3, and shall exhibit no resonance frequencies below 3000 Hz; it may be made of any suitable material, such as magnesium alloy K-1A. A test headform found to be suitable can be obtained from United States Testing Laboratories, Inc., 1415 Park Avenue, Hoboken, NJ 07030.

The impact headform shall be rigidly mounted on a base (see fig. 5) which is free to move in the direction of motion of the test bullet. The total mass of the instrumented headform and base assembly shall be 5.0±0.5 kg (11±1.1 lb) and the static force, parallel to the direction of motion, required to initiate motion of the assembly shall not exceed 9 N (2 lbf).

5.1.7 Witness Plate

The witness plates shall be 0.5 mm (0.020 in) thick, and shall be made of type 2024-T3 or 2024-T4 aluminum alloy.

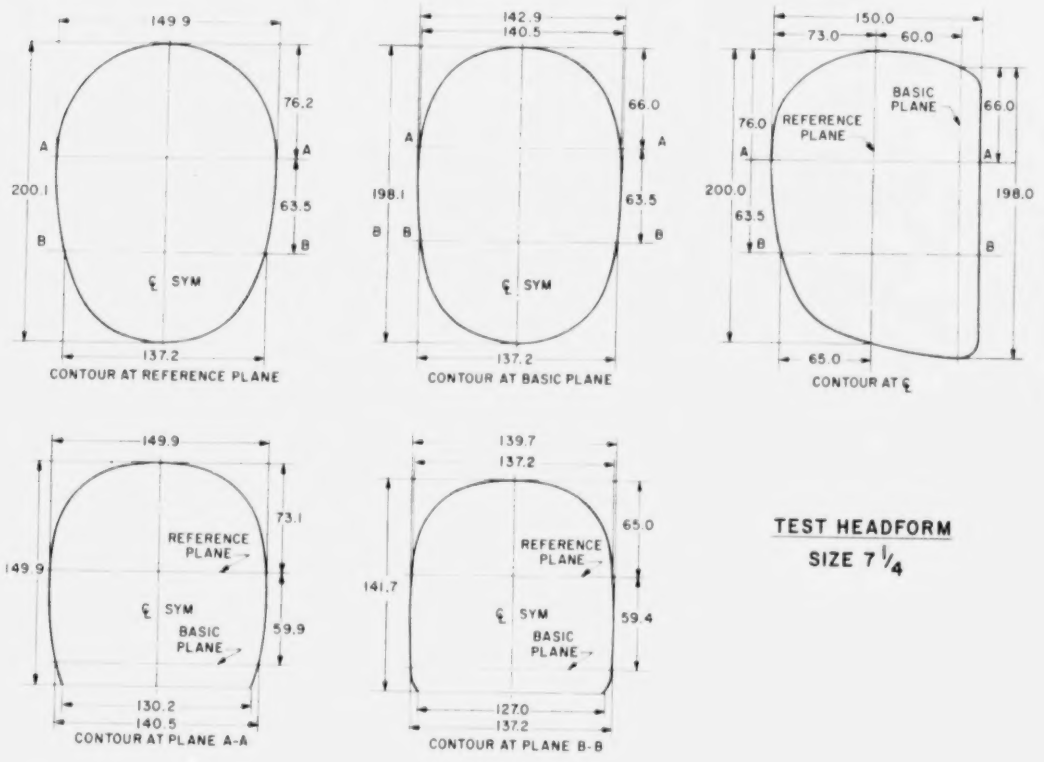

FIGURE 3. Test headform. Dimensions are in millimeters.

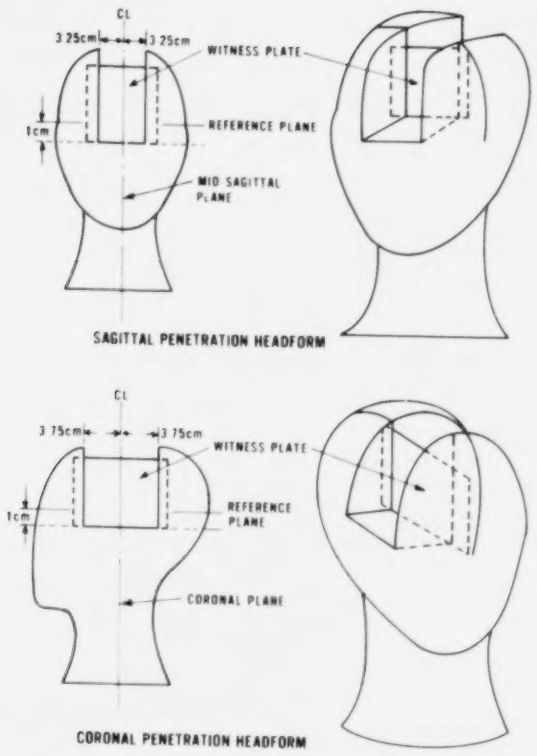

FIGURE 4. Ballistic penetration test headforms.

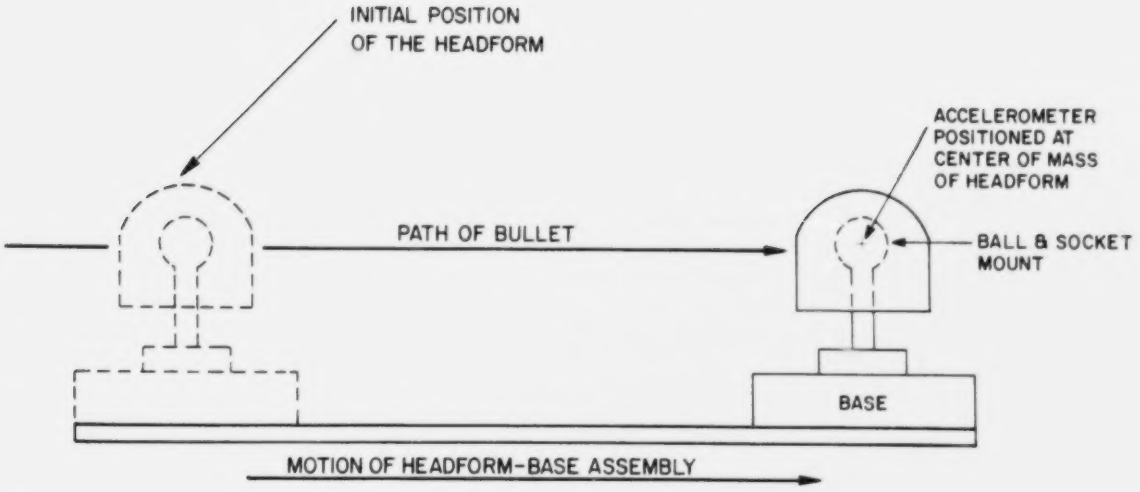
INITIAL POSITION OF THE HEADFORM
ACCELEROMETER POSITIONED AT CENTER OF MASS OF HEADFORM
PATH OF BULLET
BALL & SOCKET MOUNT
BASE
MOTION OF HEADFORM-BASE ASSEMBLY

FIGURE 5. Ballistic impact test headform—base assembly.

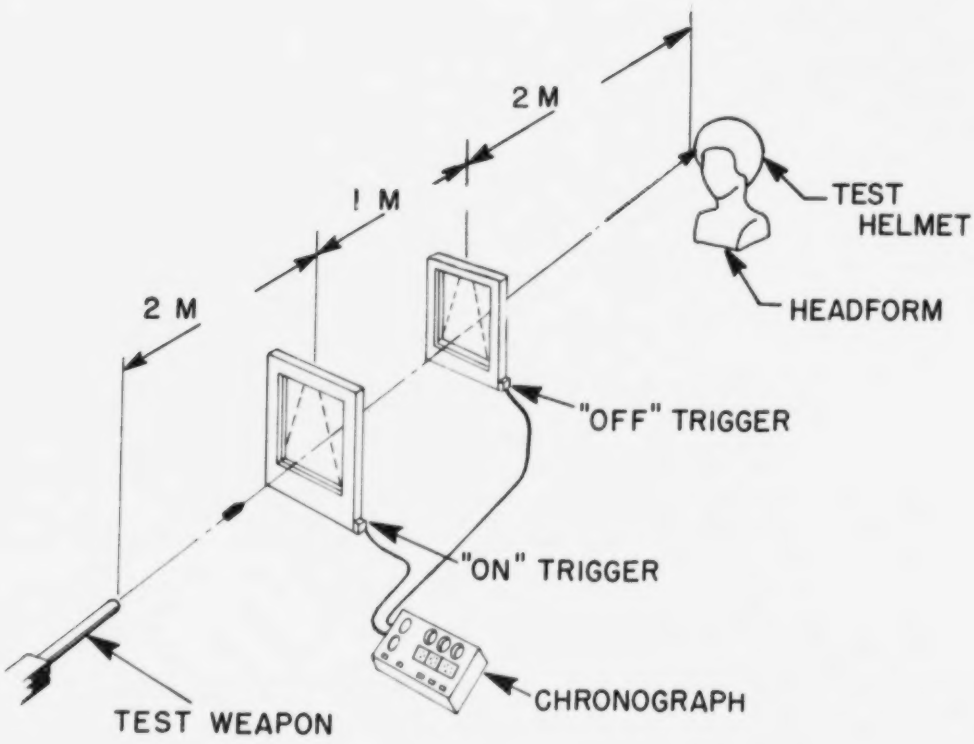

FIGURE 6. Test setup.

5.1.8 Acceleration Measurement System

The accelerometer should be able to withstand shocks up to 2000 g_n. The acceleration data channel, including all instrumentation which may alter the frequency content of the test data and all recording and analysis procedures, shall comply with SAE Recommended Practice J211b requirements for channel class 1000 [5].

5.2 Ballistic Penetration Test

Set up the test equipment as shown in figure 6. Firmly clamp the appropriate test weapon, with the barrel horizontal, in such a manner that the alignment of the weapon is not altered when it is discharged. Use the test weapon and ammunition combination in accordance with paragraphs 5.1.1.1 through 5.1.3.2 as appropriate for the threat level classification of the helmet as rated by the manufacturer in accordance with section 2.

Position a sheet of cardboard 5 m (16 ft) from the muzzle of the test weapon and fire a pre-test round through the cardboard to determine the line of flight and the point of impact of the bullet.

Place the triggering devices 2 and 3 m (6.6 and 9.8 ft), respectively, from the muzzle of the test weapon and arrange them so that they define planes perpendicular to the line of flight of the bullet. Measure the distance between them with an accuracy of 1 mm (0.04 in).

Insert a witness plate in the sagittal penetration test headform, place the helmet under test on the headform and secure it by its chin strap or by other means which will not interfere with the test. Place the helmeted headform in back of the sheet of cardboard, with the desired point of impact touching the bullet hole made by the test round, and then remove the cardboard.

Fire one round at the front of the helmet, hitting it at a point no more than 9 cm (3.5 in) above the basic plane and no more than 5 cm (2 in) from the mid-sagittal plane. Record the time of flight of the bullet between the two triggering screens, as determined by the chronograph, and calculate the bullet velocity. Then fire a round at the back of the helmet, impacting it within the area diametrically opposite the front impact area. Examine the helmet and witness plate to determine whether penetration occurred when a bullet traveling at an acceptable speed made a fair hit within the required area.

If no penetration occurred, place the helmet on the coronal penetration test headform and shoot it once on each side, at a point no more than 5 cm (2 in) above the basic plane and no more than 7.5 cm (3.0 in) from the coronal plane.

If no penetration occurs, repeat the above test on a second helmet, which has been preconditioned by immersion for 2 to 4 h in water at 25±5 °C (77±9 °F).

5.3 Ballistic Impact Attenuation Test

Set up the test equipment as shown in figure 6 and locate the line of fire and point of impact of the bullet as described in paragraph 5.2. Use the test weapon and ammunition combination in accordance with paragraphs 5.1.1.1 through 5.1.3.2 as appropriate for the threat level classification of the helmet as rated by the manufacturer in accordance with section 2.

Mount the accelerometer at the center of mass of the impact test headform in such a manner that it can be easily repositioned for all impacts; a universal ball-and-socket mount has been found to be suitable. Position the helmet squarely on the headform and secure it by its chin strap or other means which will not interfere with the test. Position the instrumented test headform-base assembly in the line of fire so that the sensitive axis of the accelerometer and the line of fire are colinear within 5°.

Allow all electronic equipment to warm up for 30 min or until stability is achieved, whichever time is greater, prior to testing, and perform the tests at an ambient temperature of 20–28 °C (68–82 °F) and a relative humidity of 30 to 70%.

Shoot four test rounds at the helmet, one at each of the four sites as described in paragraph 5.2, and measure the velocity of each fair hit and the headform acceleration which it produces.

APPENDIX A—REFERENCES

1. NILECJ-STD-0101.01, "The Ballistic Resistance of Body Armor," National Institute of Justice, U.S. Department of Justice, Washington, DC 20531 (Dec. 1978).
2. NIJ Standard-0104.01, "Riot Helmets," National Institute of Justice, U.S. Department of Justice, Washington, DC 20531 (Aug. 1980).
3. NILECJ-STD-0105.00, "Crash Helmets," National Institute of Justice, U.S. Department of Justice, Washington, DC 20531 (June 1975).
4. NIJ Standard-0108.00, "Ballistic Resistant Protective Materials." (In preparation).
5. SAE Recommended Practice J2116, Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, NY.

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